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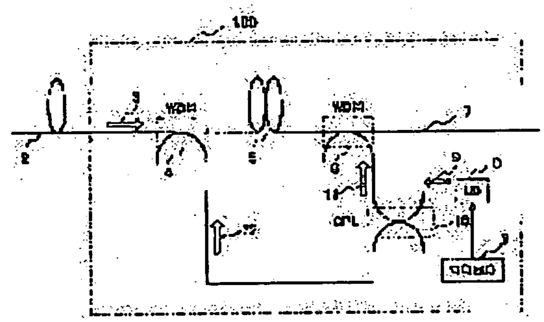
(54) OPTICAL REPEATER AND OPTICAL TRANSMISSION SYSTEM

(57)Abstract:

PROBLEM TO BE SOLVED: To provide an optical repeater with a simple constitution in which first light amplification and second light amplification can be simultaneously executed by using one exciting light source system.

SOLUTION: The optical repeater 100 to be inserted between an input line 2 and an output line 7 is constituted by successively connecting a multiplexer 4, a fiber 5 for the light amplification, and the multiplexer 6. The exciting light source 8 is provided and the excitation light 9 generated from the exciting light source 8 is dispersed to first excitation light 11 and second excitation light 12 by a spectroscope 10. A first light amplification means is constituted by injecting the first excitation light 11 to an optical signal 3 by the multiplexer 6 and a second light amplification means is constituted by injecting the second excitation light 12 outputted from the spectroscope 10 to the optical signal 3 by the multiplexer 4.



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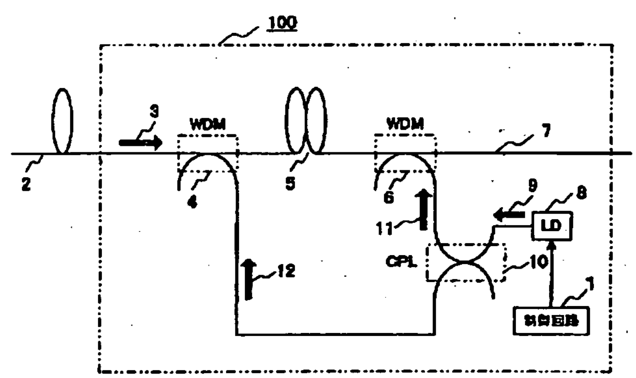
(54)【発明の名称】　光中継装置及び光伝送システム

(57)【要約】
【課題】１系統の励起光源を使用して、第１の光増幅と第２の光増幅を同時に行うことができる構成が簡易な光中継装置を提供する。
【解決手段】入力線路２と出力線路７の間に介挿される、光中継装置１００は、合波器４と光増幅用ファイバ５と合波器６とが順次に直列に接続されて構成される。励起光源８が設けられ、この励起光源８から発せられる励起光９が、分光器１０によって第１励起光１１と第２励起光１２に分光され、第１励起光１１を合波器６によって光信号３に注入することによって第１の光増幅手段が構成され、分光器１０から出力される第２励起光１２を合波器４によって光信号３に注入することによって第２の光増幅手段が構成される。



【特許請求の範囲】

【請求項１】励起光源から発せられる励起光を第１励起光と第２励起光に分光する分光手段と、
光信号が伝搬される光増幅用ファイバに前記第１励起光を注入して光増幅を行なう第１の光増幅手段と、
光増幅用ファイバに前記第２励起光を注入して光増幅を行なう第２の光増幅手段と、を具備することを特徴とする光中継装置。

【請求項２】前記第１及び第２の光増幅手段は、それぞれ前記第１励起光及び第２励起光により前方励起されることを特徴とする請求項１に記載の光中継装置。

【請求項３】前記第１の光増幅手段は前記第１励起光により前方励起され、前記第２の光増幅手段は前記第２励起光により後方励起されることを特徴とする請求項１に記載の光中継装置。

【請求項４】前記第１の光増幅手段は前記第１励起光により後方励起され、前記第２の光増幅手段は前記第２励起光により前方励起されることを特徴とする請求項１に記載の光中継装置。

【請求項５】前記第２の光増幅手段は、前記分光手段によって得られる前記第２励起光を減衰する光減衰器を含んで構成されることを特徴とする請求項１乃至請求項４のいずれかに記載の光中継装置。

【請求項６】前記分光手段は、前記第１励起光と前記第２励起光の分岐比率を可変する可変分岐器を含んで構成されることを特徴とする請求項１乃至請求項４のいずれかに記載の光中継装置。

【請求項７】前記第１の光増幅手段は、前記分光手段によって得られる前記第２励起光を減衰する光減衰器を含んで構成すると共に、
前記分光手段は、前記第１励起光と前記第２励起光の分岐比率を可変する可変分岐器を含んで構成されることを特徴とする請求項１乃至４のいずれかに記載の光中継装置。

【請求項８】前記第１の光増幅手段は、前記分光手段によって得られる前記第１励起光を増幅する光増幅器を含んで構成されることを特徴とする請求項１乃至請求項４のいずれかに記載の光中継装置。

【請求項９】前記分光手段は、前記第１励起光を生成するための複数の励起光源を含んで構成されることを特徴とする請求項１乃至４のいずれかに記載の光中継装置。

【請求項１０】前記分光手段は、前記第２励起光を生成するための複数の励起光源を含んで構成されることを特徴とする請求項１乃至４のいずれかに記載の光中継装置。

【請求項１１】前記分光手段は、複数の励起光源の出力を合成した励起光成分を前記第１励起光と前記第２励起光に分光するように構成されることを特徴とする請求項１乃至１０のいずれかに記載の光中継装置。

【請求項１２】請求項１乃至１１のいずれかに記載の光中継装置が、光信号伝送路の中継区間の少なくとも一区間に設置されていることを特徴とする光伝送システム。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、光通信システムに用いられる光中継装置及び光伝送システムに係り、光信号が伝搬される光増幅用ファイバに、励起光源から発せられる励起光を注入することによってラマン増幅する機能を有する光中継装置及び光伝送システムに関する。

【０００２】

【従来の技術】光通信の伝達距離の長距離化と、光信号の大容量化に伴って、光中継装置にラマン増幅機能を持たせて伝送特性を改善することが広く行われている。この光中継装置は、例えば特開２００１－１９４６９１に開示されているように、光ファイバを伝搬する光信号に対して励起光を注入することによってラマン増幅を行っている。

【０００３】この具体的な構成は、ラマン増幅し得る波長を有する第１励起光を発生する第１励起光源と、この第１励起光とは異なる波長を有する第２励起光を発生する第２励起光源とを別個に設けている。

【０００４】そして、光信号が伝搬される光増幅用ファイバに対して、第１励起光源で発生された第１励起光を注入して第１の光増幅を行なうと同時的に、第２励起光源で発生された第２励起光を注入して第２の光増幅を行い、これらの第１および第２の光増幅によって所定のラマン増幅機能を得ることができる。

【０００５】このようなラマン増幅を行なう場合には、光増幅用ファイバを伝搬する光信号に注入される励起光を、光信号と励起光の伝搬方向が逆となる後方励起で注入する場合と、光信号と励起光の伝搬方向が同一となる前方励起で注入する場合がある。

【０００６】また、第１励起光と第２励起光のそれぞれの波長は、本来の光信号の有する多波長の間隔と数に対応して設定されると共に、ラマン増幅するに最適な値に設定されている。

【０００７】

【発明が解決しようとする課題】従来の光中継装置は、第１および第２の光増幅によって所定のラマン増幅機能を得るに際して、第１の光増幅を行なうための第１励起光と、第２の光増幅を行なうための第２励起光のそれぞれを別個に独立した第１励起光源と第２励起光源のそれぞれで発生させている。

【０００８】したがって、励起光源を２つ設けなければならず、構成が複雑化してしまうという問題がありこの解消が望まれている。

【０００９】そこで、本発明の目的は、同じ励起光源を使用して、複数の光増幅を同時に行なうことができ、構成が簡素な光中継装置及び光伝送システムを提供することにある。

【００１０】

【課題を解決するための手段】前記課題を解決するために、本発明による光中継装置及び光伝送システムは、次に記載するような特徴的な構成を採用している。

【００１１】（１）励起光源から発せられる励起光を第１励起光と第２励起光に分光する分光手段と、光信号が伝搬される光増幅用ファイバに前記第１励起光を注入して光増幅を行なう第１の光増幅手段と、光増幅用ファイバに前記第２励起光を注入して光増幅を行なう第２の光増幅手段と、を具備する光中継装置。

【００１２】（２）前記第１及び第２の光増幅手段は、それぞれ前記第１励起光及び第２励起光により前方励起される上記（１）の光中継装置。

【００１３】（３）前記第１の光増幅手段は前記第１励起光により前方励起され、前記第２の光増幅手段は前記第２励起光により後方励起される上記（１）の光中継装置。

【００１４】（４）前記第１の光増幅手段は前記第１励起光により後方励起され、前記第２の光増幅手段は前記第２励起光により前方励起される上記（１）の光中継装置。

【００１５】（５）前記第２の光増幅手段は、前記分光手段によって得られる前記第２励起光を減衰する光減衰器を含んで構成される上記（１）乃至（４）のいずれかの光中継装置。

【００１６】（６）前記分光手段は、前記第１励起光と前記第２励起光の分岐比率を可変する可変分岐器を含んで構成される上記（１）乃至（４）のいずれかの光中継装置。

【００１７】（７）前記第１の光増幅手段は、前記分光手段によって得られる前記第２励起光を減衰する光減衰器を含んで構成されると共に、前記分光手段は、前記第１励起光と前記第２励起光の分岐比率を可変する可変分岐器を含んで構成される上記（１）乃至（４）のいずれかの光中継装置。

【００１８】（８）前記第１の光増幅手段は、前記分光手段によって得られる前記第１励起光を増幅する光増幅器を含んで構成される上記（１）乃至（４）のいずれかの光中継装置。

【００１９】（９）前記分光手段は、前記第１励起光を生成するための複数の励起光源を含んで構成される上記（１）乃至（４）のいずれかの光中継装置。

【００２０】（１０）前記分光手段は、前記第２励起光を生成するための複数の励起光源を含んで構成される上記（１）乃至（４）のいずれかの光中継装置。

【００２１】（１１）前記分光手段は、複数の励起光源の出力を合成した励起光成分を前記第１励起光と前記第２励起光に分光するように構成される上記（１）乃至（１０）のいずれかの光中継装置。

【００２２】（１２）上記（１）乃至（１１）のいずれかの光中継装置が、光信号伝送路の中継区間の少なくとも一区間に設置されている光伝送システム。

【００２３】

【発明の実施の形態】以下、本発明の実施の形態について図面を用いて詳細に説明する。先ず、第１の実施の形態について図１と図２を用いて説明する。

【００２４】入力線路２と出力線路７の間に介挿される、本発明に係る光中継装置１００においては、合波器４と、光増幅用ファイバ５と、合波器６とが順次に直列に接続されている。

【００２５】また、レーザダイオード等で構成される励起光源８が設けられ、この励起光源８から発せられる励起光９が、分光器１０によって第１励起光１１と第２励起光１２に分光され、第１励起光１１を合波器６によって光信号３に注入することによって第１の光増幅手段が構成され、分光器１０から出力される第２励起光１２を合波器４によって光信号３に注入することによって第２の光増幅手段が構成される。

【００２６】制御回路１は、例えば、外部からの制御信号により励起光源８から出力される励起強度を制御して増幅特性を最適化する。外部からの制御信号は信号光に含まれ、分岐器により分光され、受光器で電気信号に変換される。以下に説明する各実施形態の説明では、この制御回路１は、励起光源８から出力される励起強度だけでなく、他の任意の要素（増幅器等）の所望の制御を行なう。

【００２７】尚、図示していないが、光伝送路には、必要により光信号を一方向にのみ伝送するための光アイソレータが設けられていることは勿論である。

【００２８】この例は、光信号３が伝搬される光増幅用ファイバ５の出口側に該光信号３の伝搬方向と逆の方向に第１励起光１１を注入する後方励起であり、光増幅用ファイバ５の入口側に光信号３の伝搬方向と逆の方向に第２励起光を注入する後方励起の場合である。

【００２９】入力線路２を伝搬される光信号３に対して光増幅用ファイバ５の部位で第１励起光１１を注入することによって従来の光中継装置と同様に光増幅に寄与するラマン増幅が行われ、これと同時的に光増幅用ファイバ５を伝搬する光信号３に第２励起光１２が注入されることによって副次的な光増幅が行われる。

【００３０】したがって、光中継装置１における総合のラマン利得は、第１励起光１１によって形成される第１の光増幅によるラマン利得が例えば図２に示す特性Ａであった場合には、これに第２励起光１２による第２の光増幅によるラマン利得の特性Ｂが付加された特性Ｃ（Ａ＋Ｂ）とされ、トータルで大きな信号増幅効果が得られる。

【００３１】以下に説明する各実施形態でも同様であるが、本発明によれば、次のような効果も得られる。

【００３２】先ず、本発明によれば、励起光による光増

幅特性の利得改善効果が得られる。すなわち、上記増幅機能においては、励起光強度を増大させるにしたがって増幅利得が増大するので、利得を上げたいときには励起光強度を増大させれば良いが、増幅素子独自の限界、制約があるため、利得はあるレベルで飽和してしまう。例えば、図３の点線で示すように、従来の増幅器（例えば、ＥＤＦ等の光ファイバ増幅器）では、特定の励起光強度がＥ１（ｍＷ）までは利得が比例して増大するが、励起光強度がＥ１を越えると、それ以上に増大させても利得はＧ１で飽和してそれ以上には増えない。したがって、励起光を出力する光源（レーザダイオード等）に、より強度の大きな励起光を出力する余裕があっても、その余裕分を十分に活用できなかった。

【００３３】一方、本発明では、第１励起光による第１の光増幅（例えば、光ファイバ増幅器）に更に第２励起光による第２の光増幅（例えば、ラマン増幅器）を用いているため、図３の実線で示すように、励起光強度Ｅ１以上の強度Ｅ２に至るまで利得は増大し続けることになる。したがって、ラマン増幅による利得が追加され、ラマン増幅の飽和利得Ｇ２まで（励起光強度Ｅ２まで）は励起光が有効活用され、より大きな利得が得られる。

【００３４】また、本発明によれば、光増幅特性の利得傾斜の改善効果が得られる。図４には、この効果を説明するための波長と利得の関係を示す特性図が示されている。従来のアンプとしての光ファイバ増幅の利得特性が（Ａ）で示すように波長が長くなるにしたがって利得が低下する特性の場合、ラマン増幅の利得特性を、（Ｂ）に示すように、逆に波長が長くなるにしたがって高くなるように調整すれば、結局、両特性の傾斜が打ち消しあってトータルでは略一定の利得特性（Ａ+Ｂ）が得られる。このトータルな特性は、増幅特性を任意に調整すれば、所望の特性とすることができる。

【００３５】更に、本発明によれば、光増幅特性の帯域拡大効果が得られる。波長と利得の関係を示す図５を参照して、この効果を説明する。図５は図４と同様な図であるが、トータル特性には傾斜がある。

【００３６】システム設計上許容される利得差をΔＧとすると、従来アンプとしての光ファイバ増幅を用いた場合の特性（Ａ）の波長帯域はＡとなる。一方、本発明におけるラマン増幅による特性（Ｂ）を考慮すると、トータル特性（Ｃ）の傾斜が緩やかとなり、結局、許容利得差をΔＧ´とすると、従来の光ファイバ増幅を用いた場合の波長帯域はＡに波長帯域Ｂが付加されてトータルの波長帯域はＣ（＝Ａ+Ｂ）となり著しい帯域拡大効果が得られる。

【００３７】以上の各種効果は以下に説明するすべての実施形態においても同様に得られる。

【００３８】次に、本発明の第２の実施の形態による光中継装置１０１について図６を用いて説明する。本実施形態は、図１に示す光中継装置１００の構成の一部を変更した光中継器１０１である。すなわち、分光器１０から出力される第２励起光１２を合波器４に注入するに際して、第２励起光１２の線路中に光減衰器１３を介挿することによって第２の光増幅手段を構成したものである。

【００３９】したがって、分光器１０から出力される第２励起光１２の出力を光減衰器１３によって調節することによって得られる減衰光１４を合波器４によって光信号３に注入することにより、第２励起光１２による第２の光増幅によるラマン利得を最適な値に設定することができる。

【００４０】制御回路１は、外部からの制御信号により励起光源８から出力される励起強度及び光減衰器１３の減衰レベルを制御して増幅特性を最適化する。

【００４１】次に、本発明の第３の実施の形態による光中継装置１０２について図７を用いて説明する。本実施形態は、図１に示す光中継装置１の構成の一部を変更した光中継器１０２で、励起光源８から発せられる励起光９を２つの励起光に分光するに際して、その分岐比を可変し得るような可変分岐器１５を含んで分光手段を構成したものである。

【００４２】この可変分岐器１５は、励起光源８から出力される励起光９を第１励起光１１と第２励起光１６に分光する際に、その分岐比を可変できるようにしたもので、可変分岐器１５から出力される第２励起光１６の出力を最適な値に調整した状態で合波器４に注入することによって、第２励起光１６による第２の光増幅によるラマン利得を最適な値に保つことができる。これに連動して、第１励起光１１の分岐比も可変分岐器１５によって最適な値にされているので第１励起光１１による第１の光増幅によるラマン利得も最適な値に保つことができる。

【００４３】制御回路１は、外部からの制御信号により励起光源８から出力される励起強度及び可変分岐器１５を制御して増幅特性を最適化する。

【００４４】次に、本発明の第４の実施の形態による光中継装置１０３について図８を用いて説明する。本実施形態は、図２に示す第２の実施の形態による機能と、図６に示す第３の実施の形態による機能とを兼ね備えるように組み合わせて図８に示すような光中継装置１０３として構成したもので、励起光源８から発せられる励起光９を可変分岐器１７により第１励起光１１と分岐光１８の２つに分岐し、この分岐光１８の経路の後段に光減衰器１９を介挿することによって第２の光増幅手段を構成したものである。

【００４５】また、光中継装置１０３は、励起光源８から発せられる励起光９を２つの励起光に分光するに際して、その分岐比を可変し得るような可変分岐器１７を含んで分光手段を構成したものである。

【００４６】したがって、可変分岐器１７から出力され

る分岐光１８の出力を光減衰器１９によって調節することによって得られる第２励起光２０を合波器４によって光信号３に注入することにより、第２励起光２０による第２の光増幅によるラマン利得を最適な値に設定することができる。

【００４７】また、可変分岐器１７は、励起光源８から出力される励起光９を第１励起光１１と分岐光１８の２つに分光する際に、その分岐比を可変できるので、可変分岐器１７から出力される分岐光１８の出力を最適な分岐比に調整した状態で合波器４に注入されるので、第２励起光２０による第２の光増幅によるラマン利得を最適な値に保つことができる。これに連動して、第１励起光１１の分岐比も可変分岐器１７によって最適な値にされているので第１励起光１１による第１の光増幅によるラマン利得も最適な値に保つことができる。

【００４８】入力線路２を伝搬される光信号３に対して光増幅用ファイバ５の部位で第１励起光１１が注入されることによって従来の光中継装置と同様に光増幅に寄与するラマン増幅が行われ、これと同時的に光増幅用ファイバ５を伝搬する光信号３に第２励起光２０が注入されることによって副次的な光増幅が行われる。

【００４９】制御回路１は、外部からの制御信号により励起光源８から出力される励起強度、可変分岐器１７及び光減衰器１９の減衰レベルを制御して増幅特性を最適化する。

【００５０】次に、本発明の第５の実施の形態による光中継装置１０４について図９を用いて説明する。本実施形態は、図１に示す光中継装置１０１の構成の一部を変更して光中継装置１０４を構成したもので、すなわち、分光器１０から出力される第２励起光１２を合波器４に注入するに際して、第２励起光１２の線路中に光増幅器２１を介挿することによって第２の光増幅手段を構成したものである。

【００５１】したがって、分光器１０から出力される第２励起光１２の出力を光増幅器２１によって調節することによって得られる増幅光２２を合波器４によって光信号３に注入することにより、第２励起光１２に基づく第２の光増幅によるラマン利得を最適な値に設定することができる。

【００５２】制御回路１は、外部からの制御信号により励起光源８から出力される励起強度及び光増幅器２１を制御して増幅特性を最適化する。

【００５３】次に、本発明の第６の実施の形態による光中継装置１０５を説明する。本実施形態は、図１に示される第１の実施の形態の光中継装置１０１の構成の一部を変更し、図１０に示す光中継装置１０５のように構成したものである。

【００５４】すなわち、光中継装置１０５は、光増幅用ファイバ５に対して第１励起光１１の注入を行なう状態を前方励起としたもので、励起光源２３から発せられる励起光２４が分光器１０によって第１励起光１１と第２励起光１２に分光され、この第１励起光１１が光信号３の伝搬方向と同一の方向に合波器６を用いて注入されて前方励起の状態でラマン増幅が行われる。

【００５５】一方、分光器１０で分光された第２励起光１２は、図１に示すと同様に、光信号３の伝搬方向と同一の方向に合波器４を用いて注入されて後方励起の状態で副次的なラマン増幅が行われる。

【００５６】制御回路１は、外部からの制御信号により励起光源２３から出力される励起強度を制御して増幅特性を最適化する。

【００５７】次に、本発明の第７の実施の形態による光中継装置１０６について図１１を用いて説明する。本実施形態は、図６に示す光中継装置１０１の構成の一部を変更して図１１に示す光中継装置１０６としたもので、すなわち、分光器１０から出力される第２励起光１２を合波器４に注入するに際して、第２励起光１２の線路中に光減衰器１３を介挿することによって第２の光増幅手段を構成すると共に、光中継装置１０６は、光増幅用ファイバ５に対して第１励起光１１の注入を行なう状態を前方励起としたもので、励起光源２５から発せられる励起光２６が分光器１０によって第１励起光１１と第２励起光１２に分光され、この第１励起光１１が光信号３の伝搬方向と同一の方向に合波器６を用いて注入されて前方励起の状態でラマン増幅が行われる。

【００５８】一方、分光器１０で分光された第２励起光１２は、光減衰器１３によって調節することによって得られる減衰光１４を合波器４によって光信号３の伝搬方向と逆の方向に後方励起の状態で合波器６を用いて注入されることにより、第２励起光１２による第２の光増幅によるラマン利得を最適な値に設定することができる。

【００５９】制御回路１は、外部からの制御信号により励起光源２５から出力される励起強度及び光減衰器１３の減衰レベルを制御して増幅特性を最適化する。

【００６０】次に、本発明の第８の実施の形態による光中継装置１０７について図１２を用いて説明する。本実施形態は、図７に示す光中継装置１０２の構成の一部を変更して図９に示す光中継装置１０７としたもので、すなわち、励起光源２７から発せられる励起光２８を２つの励起光に分光するに際して、その分岐比を可変し得るような可変分岐器１５を含んで分光手段を構成すると共に、この可変分岐器１５によって最適値に可変分岐された第１励起光１１を光信号３に注入に際して当該光信号３の伝搬方向と同一の方向に前方励起の状態で注入してラマン増幅を行なうものである。

【００６１】また、可変分岐器１５から出力される分岐光１６を合波器４に注入するに際しては、光信号３の伝搬方向と逆の方向に後方励起の状態で合波器４を用いて注入された状態でラマン増幅が行われる。

【００６２】この場合、可変分岐器１５は、励起光源２

７から出力される励起光２８を第１励起光１１と第２励起光１６に分光する際に、その分岐比を可変できるようにしたもので、可変分岐器１５から出力される第２励起光１６の出力を最適な値に調整した状態で合波器４に注入することによって、第２励起光１６による第２の光増幅によるラマン利得を最適な値に保つことができる。これに連動して、第１励起光１１の分岐比も可変分岐器１５によって最適な値にされているので第１励起光１１による第１の光増幅によるラマン利得も最適な値に保つことができる。

【００６３】制御回路１は、外部からの制御信号により励起光源２７から出力される励起強度及び可変分岐器１５を制御して増幅特性を最適化する。

【００６４】次に、本発明の第９の実施の形態による光中継装置１０８について図１３を用いて説明する。本実施形態は、図８に示す第４の実施の形態による光中継装置１０３の構成の一部を変更して図１３に示すような光中継装置１０８としたもので、すなわち、励起光源２９から発せられる励起光３０を可変分岐器１７により、分岐比が最適に設定されて得られた第１励起光１１と分岐光１８の内の分岐光１８を合波器４側に注入するに際して、その線路中に光減衰器１９が介挿されることによって第２の光増幅手段が構成される。

【００６５】また、この光中継装置１０８は、光増幅用ファイバ５に対して第１励起光１１の注入を行なう状態を前方励起としたもので、励起光源２９から発せられる励起光３０が可変分岐器１７によって第１励起光１１と分岐光１８に分光され、この第１励起光１１が光信号３の伝搬方向と同一の方向に合波器６を用いて注入されて前方励起の状態でラマン増幅が行われる。

【００６６】一方、可変分岐器１７で分光された分岐光１８は、光減衰器１９によって調節することによって得られる第２励起光２０を合波器４によって光信号３の伝搬方向と逆の方向に後方励起の状態で注入されることにより、第２励起光１２による第２の光増幅によるラマン利得を最適な値に設定することができる。

【００６７】制御回路１は、外部からの制御信号により励起光源２９から出力される励起強度、可変分岐器１７及び光減衰器１９の減衰レベルを制御して増幅特性を最適化する。

【００６８】次に、本発明の第１０の実施の形態による光中継装置１０９について図１４を用いて説明する。本実施形態は、図６に示す光中継装置１０４の構成の一部を変更して図１１に示すような光中継装置１０９を構成したもので、すなわち、励起光源３１から発せられる励起光３２を分光器１０で分光して出力される第２励起光１２を合波器４に注入するに際して、第２励起光１２の線路中に光増幅器２１を介挿することによって第２の光増幅手段を構成したものである。

【００６９】また、この光中継装置１０９は、光増幅用ファイバ５に対して第１励起光１１の注入を行なう状態を前方励起とし、光増幅器２１による増幅光２２を合波器４に入力する際には、光信号３の伝搬方向と逆の方向に後方励起の状態で注入が行われるように構成されている。

【００７０】したがって、励起光源３１から発せられる励起光３２が分光器１０によって第１励起光１１と第２励起光１２に分光され、この第１励起光１１が光信号３の伝搬方向と同一の方向に合波器６を用いて注入されて前方励起の状態でラマン増幅が行われる。

【００７１】一方、分光器１０で分光された第２励起光１２は、光増幅器２１によって最適な増幅率に調節されて得られた増幅光２２を合波器４によって光信号３の伝搬方向と逆の方向に後方励起の状態で注入されることにより、第２励起光１２による第２の光増幅によるラマン利得を最適な値に設定することができる。

【００７２】制御回路１は、外部からの制御信号により励起光源６１から出力される励起強度を制御して増幅特性を最適化する。

【００７３】次に、本発明の第１１の実施の形態による光中継装置１１０について図１５を用いて説明する。第１の入力線路４１と第１の出力線路４６の間に、図１に示すと同様な合波器４３と、光増幅用ファイバ４４と、合波器４５を順次に接続して第１の光伝送系を構成し、同時に、第２の入力線路５１と第２の出力線路５６の間にも、図１に示すと同様な合波器５３と、光増幅用ファイバ５４と、合波器５５を順次に接続して第２の光伝送系を構成し、これらに光中継装置１１０を介挿して構成されている。

【００７４】このような第１および第２の光伝送系のそれぞれに対してラマン増幅するための分光手段が設けられている。

【００７５】この分光手段は、励起光源６１から発せられた励起光６２が分光器６３で第１励起光６４と第２励起光６５に分光され、その第１励起光６４を分光器６６で第１光６７と第２光６８に分岐し、第１光６７を合波器４５により第１の光信号４２に後方励起の状態で注入し、第２光６８を合波器５５を用いて第２の光信号５２に後方励起の状態で注入する第１の光増幅手段が構成される。

【００７６】また、分光器６３で分岐された第２励起光６５は、分光器６９で第１光７０と第２光７１に分岐され、第１光７０を合波器４３により第１の光信号４２に後方励起の状態で注入し、第２光７１を合波器５３により第２の光信号５２に後方励起の状態で注入する第２の光増幅手段が構成される。

【００７７】制御回路１は、外部からの制御信号により励起光源６１から出力される励起強度を制御して増幅特性を最適化する。

【００７８】したがって、１つの励起光源６１からの励

起光６２を用いて、第１および第２の光伝送系のそれぞれに対してラマン増幅することができ、当該の分光手段を２系統に共用して用いることができるので構成の共用化を図ることができる。

【００７９】次に、本発明の第１２の実施の形態による光中継装置１１１について図１６を用いて説明する。この形態は、分光手段の構成を複数の励起光源から発せられる複数の励起光を合成して分光することによって第１励起光と第２励起光を作り出すようにしたものである。

【００８０】すなわち、入力線路２と出力線路７の間に介挿される光中継装置１１１には、第１励起光源８１と第２励起光源８２が設けられ、その出力が合成器８５で合成され合成光８７として分光器８８に入力され、第１励起光９０が作り出される。

【００８１】一方、第３励起光源８３と第４励起光源８４が設けられ、その出力が合成器８６で合成され合成光８９として分光器８８に入力され、分岐光８８が作り出される。この分岐光８８は、光減衰器９２によって減衰されることによって第２励起光９３が作り出される。

【００８２】したがって、第１励起光源８１と第２励起光源８２のそれぞれの出力を合成してなる第１励起光９０が、合波器６を用いて光信号３に後方励起の状態で注入されることによって第１の光増幅手段によるラマン増幅が行われる。

【００８３】これと同時的に第３励起光源８３と第４励起光源８４のそれぞれの出力を合成した後に最適値に減衰されてなる第２励起光９３が、合波器４を用いて光信号３に後方励起の状態で注入されることによって第２の光増幅手段による副次的なラマン増幅が行われる。

【００８４】制御回路１は、外部からの制御信号により励起光源８１～８４から出力される励起強度及び光減衰器９２の減衰レベルを制御して増幅特性を最適化する。

【００８５】以上のような光中継装置が伝送路に沿って所定間隔で配設されて上記の如き特徴、優位性をもった光伝送システムが構成される。この光中継装置の配設は任意であり、いずれかの中継区間に配設することができる。

【００８６】

【発明の効果】以上の説明で明らかなように、本発明による光中継装置は、第１および第２の光増幅によって所定のラマン増幅機能を得るに際して、１系統の励起光源から発せられる励起光を分光器でもって第１の光増幅を行なうための第１励起光と、第２の光増幅を行なうための第２励起光のそれぞれを作り出しているために、構成の簡略化が図れるだけでなく、当該第１励起光と第２励起光を調整することにより最適な特性が得られる。

【００８７】したがって、本発明によれば、１系統の励起光源を使用して、第１の光増幅と第２の光増幅を同時的に行なうことができる光中継装置及び光伝送システムを提供することができる。

【図面の簡単な説明】

【図１】本発明の第１の実施の形態による光中継装置の構成を示すブロック図である。

【図２】本発明による光中継装置のラマン増幅特性を示す特性図である。

【図３】本発明における励起光による光増幅特性の利得改善効果を説明するための特性図である。

【図４】本発明における光増幅特性の利得傾斜の改善効果を説明するための図である。

【図５】本発明における光増幅特性の帯域拡大効果を説明するための特性図である。

【図６】本発明の第２の実施の形態による光中継装置の構成を示すブロック図である。

【図７】本発明の第３の実施の形態による光中継装置の構成を示すブロック図である。

【図８】本発明の第４の実施の形態による光中継装置の構成を示すブロック図である。

【図９】本発明の第５の実施の形態による光中継装置の構成を示すブロック図である。

【図１０】本発明の第６の実施の形態による光中継装置の構成を示すブロック図である。

【図１１】本発明の第７の実施の形態による光中継装置の構成を示すブロック図である。

【図１２】本発明の第８の実施の形態による光中継装置の構成を示すブロック図である。

【図１３】本発明の第９の実施の形態による光中継装置の構成を示すブロック図である。

【図１４】本発明の第１０の実施の形態による光中継装置の構成を示すブロック図である。

【図１５】本発明の第１１の実施の形態による光中継装置の構成を示すブロック図である。

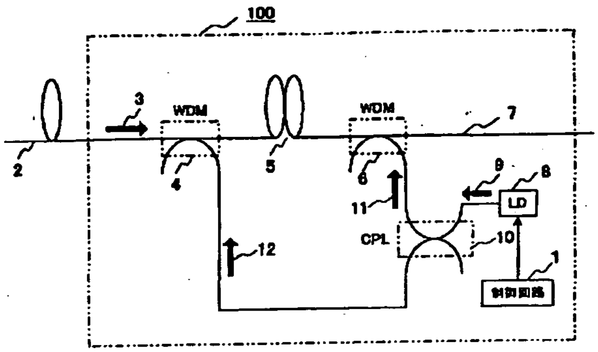
【図１６】本発明の第１２の実施の形態による光中継装置の構成を示すブロック図である。

【符号の説明】

１００～１１１	光中継装置
１	制御回路
２	入力線路
３	光信号
４、６	合波器
５	光増幅用ファイバ
７	出力線路
８、２３、２５、２７、２９、３１、６１、８１～８４	励起光源
９	励起光
１０	分光器
１５、１７	可変分岐器
１１	第１励起光
１２	第２励起光
１３、１９、９３	光減衰器
２１	光増幅器

８５、８６　　　合成器

【図１】



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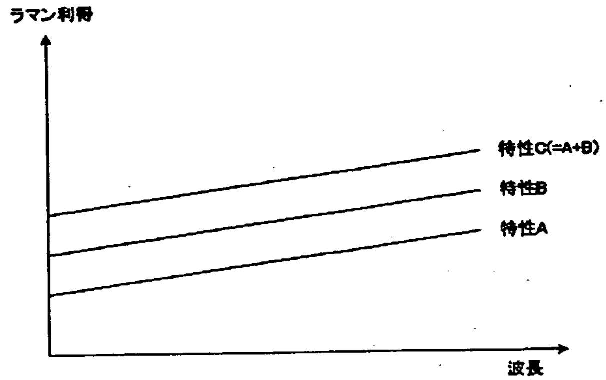

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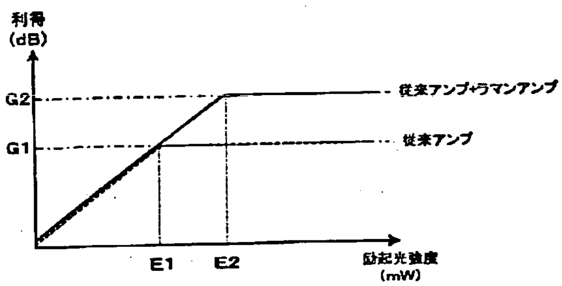

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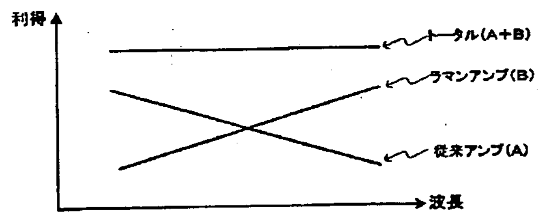

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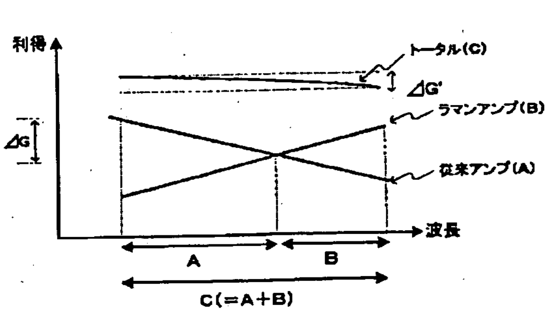

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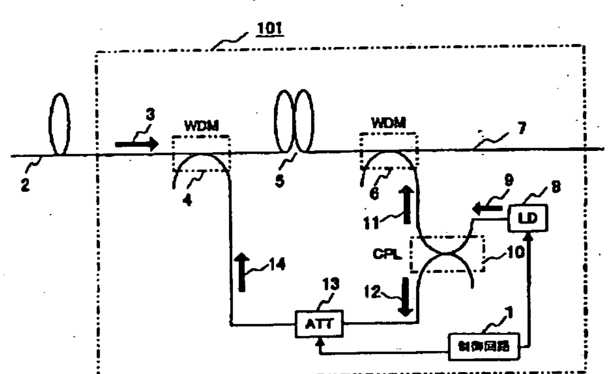

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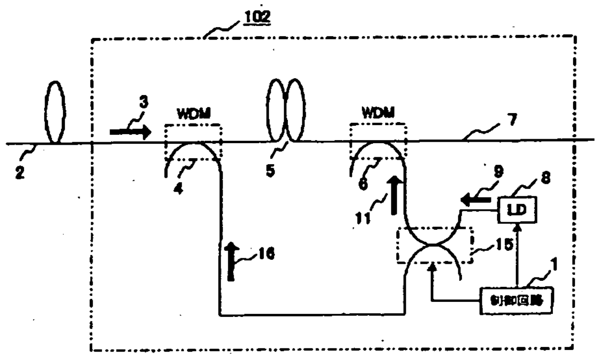

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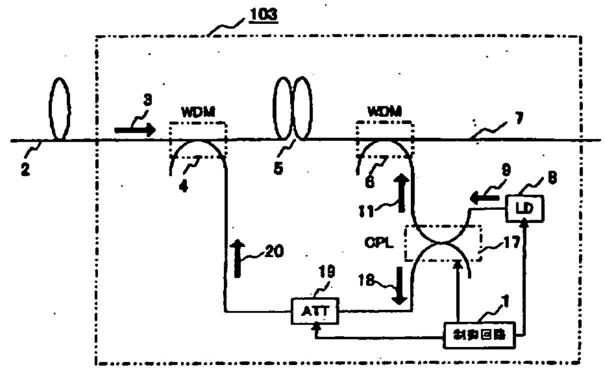

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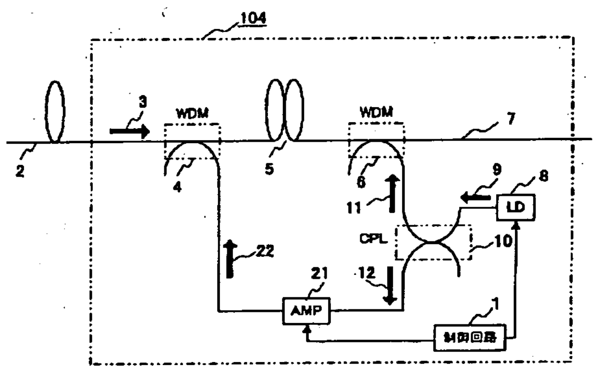
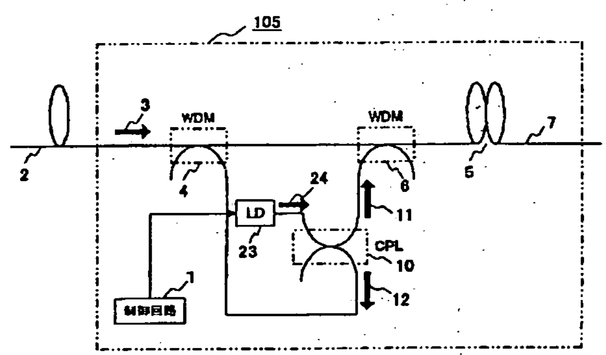
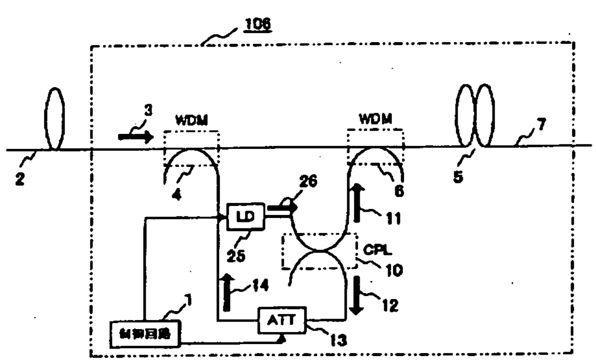


【図１０】



【図１１】



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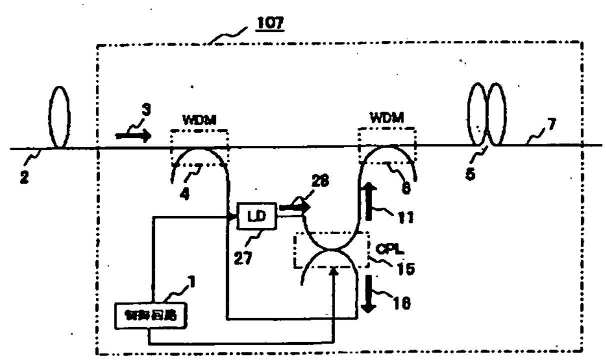

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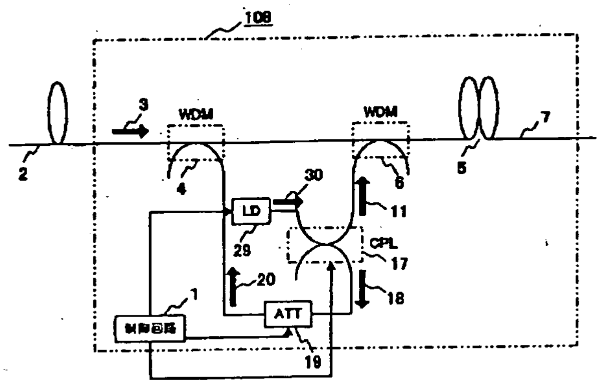

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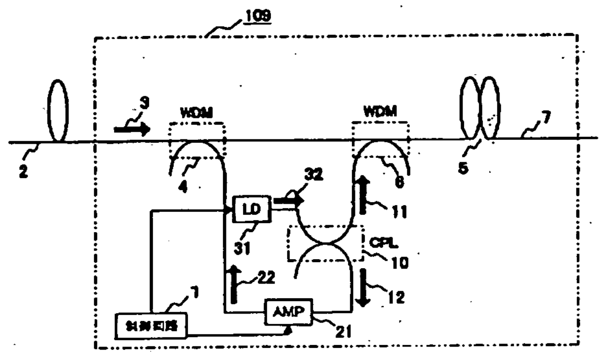

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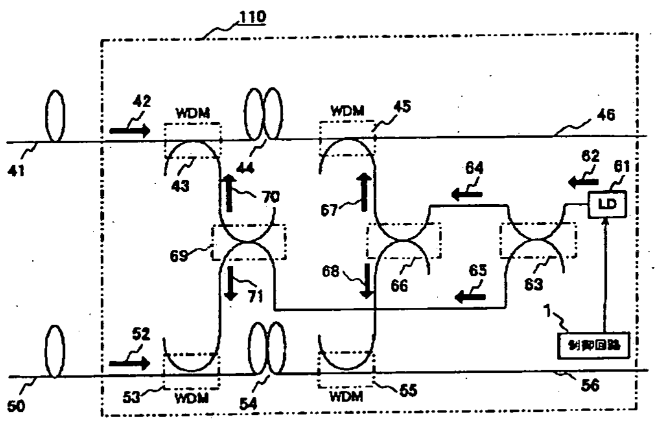

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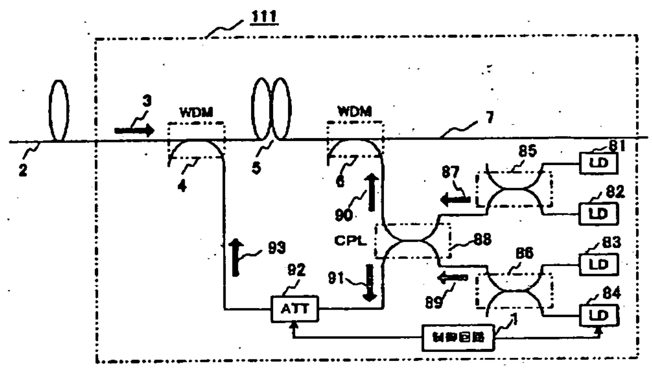

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(72)Inventor :
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(54) OPTICAL REPEATER AND OPTICAL TRANSMISSION SYSTEM

(57)Abstract:
PROBLEM TO BE SOLVED: To provide an optical repeater with a simple constitution in which first light amplification and second light amplification can be simultaneously executed by using one exciting light source system.
SOLUTION: The optical repeater 100 to be inserted between an input line 2 and an output line 7 is constituted by successively connecting a multiplexer 4, a fiber 5 for the light amplification, and the multiplexer 6. The exciting light source 8 is provided and the excitation light 9 generated from the exciting light source 8 is dispersed to first excitation light 11 and second excitation light 12 by a spectroscope 10. A first light amplification means is constituted by injecting the first excitation light 11 to an optical signal 3 by the multiplexer 6 and a second light amplification means is constituted by injecting the second excitation light 12 outputted from the spectroscope 10 to the optical signal 3 by the multiplexer 4.

LEGAL STATUS
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CLAIMS

[Claim(s)]
[Claim 1] the spectrum which carries out the spectrum of the excitation light emitted from the excitation light source to the 1st excitation light and the 2nd excitation light -- the optical repeating installation characterized by to provide a means, the 1st optical-amplification means which pours said 1st excitation light into the fiber for optical amplification spread by the lightwave signal, and performs optical amplification, and the 2nd optical-amplification means which pours said 2nd excitation light into the fiber for optical amplification, and performs optical amplification.
[Claim 2] Said 1st and 2nd optical amplification means are optical repeating installation according to claim 1 characterized by front excitation being carried out by said 1st excitation light and the 2nd excitation light, respectively.
[Claim 3] It is the optical repeating installation according to claim 1 which front excitation of said 1st optical amplification means is carried out by said 1st excitation light, and is characterized by back excitation of said 2nd optical amplification means being carried out by said 2nd excitation light.
[Claim 4] It is the optical repeating installation according to claim 1 which back

excitation of said 1st optical amplification means is carried out by said 1st excitation light, and is characterized by front excitation of said 2nd optical amplification means being carried out by said 2nd excitation light.
[Claim 5] said 2nd optical amplification means -- said spectrum -- the optical repeating installation according to claim 1 to 4 characterized by being constituted including the optical attenuator which decreases said 2nd excitation light obtained by the means.
[Claim 6] said spectrum -- the optical repeating installation according to claim 1 to 4 characterized by constituting a means including the adjustable turnout which carries out adjustable [of the rate of a branching ratio of said 1st excitation light and said 2nd excitation light].
[Claim 7] said 1st optical amplification means -- said spectrum -- while constituting including the optical attenuator which decreases said 2nd excitation light obtained by the means -- said spectrum -- the optical repeating installation according to claim 1 to 4 characterized by constituting a means including the adjustable turnout which carries out adjustable [of the rate of a branching ratio of said 1st excitation light and said 2nd excitation light].
[Claim 8] said 1st optical amplification means -- said spectrum -- the optical repeating installation according to claim 1 to 4 characterized by being constituted including the optical amplifier which amplifies said 1st excitation light obtained by the means.
[Claim 9] said spectrum -- the optical repeating installation according to claim 1 to 4 characterized by constituting a means including two or more excitation light sources for generating said 1st excitation light.
[Claim 10] said spectrum -- the optical repeating installation according to claim 1 to 4 characterized by constituting a means including two or more excitation light sources for generating said 2nd excitation light.
[Claim 11] said spectrum -- the optical repeating installation according to claim 1 to 10 characterized by constituting a means so that the spectrum of the part for excitation Mitsunari which compounded the output of two or more excitation light sources may be carried out to said 1st excitation light and said 2nd excitation light.
[Claim 12] The lightwave transmission system characterized by installing optical repeating installation according to claim 1 to 11 in the at least 1 of the junction section of a lightwave signal transmission line section.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the optical repeating installation and the lightwave transmission system which are used for an optical transmission system, and relates to the optical repeating installation and the lightwave transmission system which have the function which carries out Raman magnification by pouring the excitation light emitted from the excitation light source into the fiber for optical amplification spread by the lightwave signal.
[0002]
[Description of the Prior Art] Giving the Raman magnification function to optical repeating installation, and improving a transmission characteristic with long-distance-izing of the transfer distance of optical communication and large-capacity-izing of a lightwave signal, is performed widely. This optical repeating installation is performing Raman magnification by pouring in excitation light to the lightwave signal which spreads an optical fiber as indicated by JP,2001-194691,A.
[0003] This concrete configuration has prepared separately the 1st excitation light source which generates the 1st excitation light which has the wavelength which can carry out Raman magnification, and the 2nd excitation light source which generates the 2nd excitation light which has different wavelength from this 1st excitation light.
[0004] And if the 1st excitation light generated in the 1st excitation light source is poured in to the fiber for optical amplification spread by the lightwave signal and the 1st optical amplification is performed, the 2nd excitation light generated in the 2nd excitation light source can be poured in instantaneous, the 2nd optical amplification can be performed, and the predetermined Raman magnification function can be obtained by such 1st and 2nd optical amplification.
[0005] When performing such Raman magnification, it may pour in by the front excitation to which the propagation direction of the case where the excitation light poured into the lightwave signal which spreads the fiber for optical amplification is poured in by the back excitation to which the propagation direction of a lightwave signal and excitation light becomes reverse, and a lightwave signal and excitation light becomes the same.
[0006] Moreover, each wavelength of the 1st excitation light and the 2nd excitation light is set as the optimal value for carrying out Raman magnification while it is set up corresponding to spacing and the number of many wavelength which an original lightwave signal has.
[0007]
[Problem(s) to be Solved by the Invention] The conventional optical repeating installation faces obtaining the predetermined Raman magnification function by the 1st and 2nd optical amplification, and is generating each of the 1st excitation light for performing the 1st optical amplification, and the 2nd excitation light for performing the 2nd optical amplification in each of the 1st excitation light source which became independent separately, and the 2nd excitation light source.

[0008] Therefore, the two excitation light sources must be prepared, there is a problem that a configuration will be complicated, and this dissolution is desired.
[0009] Then, the purpose of this invention can use the same excitation light source, and can perform two or more optical amplification to coincidence, and offering simple optical repeating installation and a simple lightwave transmission system has a configuration.
[0010]
[Means for Solving the Problem] In order to solve said technical problem, a characteristic configuration which is indicated below is used for the optical repeating installation and the lightwave transmission system by this invention.
[0011] (1) the spectrum which carries out the spectrum of the excitation light emitted from the excitation light source to the 1st excitation light and the 2nd excitation light -- the optical repeating installation possessing a means, the 1st optical amplification means which pours said 1st excitation light into the fiber for optical amplification spread by the lightwave signal, and performs optical amplification, and the 2nd optical amplification means which pours said 2nd excitation light into the fiber for optical amplification, and performs optical amplification.
[0012] (2) Said 1st and 2nd optical amplification means are the optical repeating installation of the above (1) in which front excitation is carried out by said 1st excitation light and the 2nd excitation light, respectively.
[0013] (3) It is the optical repeating installation of the above (1) with which front excitation of said 1st optical amplification means is carried out by said 1st excitation light, and back excitation of said 2nd optical amplification means is carried out by said 2nd excitation light.
[0014] (4) It is the optical repeating installation of the above (1) with which back excitation of said 1st optical amplification means is carried out by said 1st excitation light, and front excitation of said 2nd optical amplification means is carried out by said 2nd excitation light.
[0015] (5) said 2nd optical amplification means -- said spectrum -- the above (1) constituted including the optical attenuator which decreases said 2nd excitation light obtained by the means thru/or one optical repeating installation of (4).
[0016] (6) said spectrum -- the above (1) constituted including the adjustable turnout to which a means carries out adjustable [of the rate of a branching ratio of said 1st excitation light and said 2nd excitation light] thru/or one optical repeating installation of (4).
[0017] (7) said 1st optical amplification means -- said spectrum -- while being constituted including the optical attenuator which decreases said 2nd excitation light obtained by the means -- said spectrum -- the above (1) constituted including the adjustable turnout to which a means carries out adjustable [of the rate of a branching ratio of said 1st excitation light and said 2nd excitation light] thru/or one optical repeating installation of (4).
[0018] (8) said 1st optical amplification means -- said spectrum -- the above (1) constituted including the optical amplifier which amplifies said 1st excitation light obtained by the means thru/or one optical repeating installation of (4).

[0019] (9) said spectrum -- the above (1) constituted including two or more excitation light sources for a means to generate said 1st excitation light thru/or one optical repeating installation of (4).
[0020] (10) said spectrum -- the above (1) constituted including two or more excitation light sources for a means to generate said 2nd excitation light thru/or one optical repeating installation of (4).
[0021] (11) said spectrum -- the above (1) constituted so that a means may carry out the spectrum of the part for excitation Mitsunari which compounded the output of two or more excitation light sources to said 1st excitation light and said 2nd excitation light thru/or one optical repeating installation of (10).
[0022] (12) The lightwave transmission system with which the above (1) thru/or one optical repeating installation of (11) are installed in the at least 1 of the junction section of a lightwave signal transmission line section.
[0023]
[Embodiment of the Invention] Hereafter, the gestalt of operation of this invention is explained to a detail using a drawing. First, the gestalt of the 1st operation is explained using drawing 1 and drawing 2 .
[0024] In the optical repeating installation 100 concerning this invention inserted between the input-line way 2 and the output track 7, the multiplexing machine 4, the fiber 5 for optical amplification, and the multiplexing machine 6 are connected to the serial one by one.
[0025] Moreover, the excitation light 9 which the excitation light source 8 which consists of laser diodes etc. is formed, and is emitted from this excitation light source 8 A spectrum is carried out to the 1st excitation light 11 and the 2nd excitation light 12 with a spectroscope 10, and the 1st optical amplification means is constituted by pouring the 1st excitation light 11 into a lightwave signal 3 with the multiplexing vessel 6. The 2nd optical amplification means is constituted by pouring into a lightwave signal 3 the 2nd excitation light 12 outputted from a spectroscope 10 with the multiplexing vessel 4.
[0026] A control circuit 1 controls the excitation reinforcement outputted from the excitation light source 8 by the control signal from the outside, and optimizes a magnification property. The control signal from the outside is included in signal light, and a spectrum is carried out by the turnout, and it is changed into an electrical signal by the electric eye. This control circuit 1 controls the request of the elements (amplifier etc.) of not only the excitation reinforcement outputted from the excitation light source 8 but other arbitration by explanation of each operation gestalt explained below.
[0027] In addition, although not illustrated, of course, the optical isolator for transmitting a lightwave signal only to an one direction as occasion demands is formed in the optical transmission line.
[0028] This example is back excitation which pours in the 1st excitation light 11 in the direction contrary to the propagation direction of this lightwave signal 3 at the outlet side of the fiber 5 for optical amplification spread by the lightwave signal 3, and is the case of the back excitation which injects the 2nd excitation light into the entrance side of the fiber 5 for optical amplification in the direction contrary to the

propagation direction of a lightwave signal 3.

[0029] By pouring in the 1st excitation light 11 by the part of the fiber 5 for optical amplification to the lightwave signal 3 by which the input-line way 2 is spread, Raman magnification which contributes to optical amplification like the conventional optical repeating installation is performed, and secondary optical amplification is performed by pouring the 2nd excitation light 12 into the lightwave signal 3 which spreads the fiber 5 for optical amplification on this and a coincidence target.

[0030] Therefore, Raman gain of the synthesis in the optical repeating installation 1 is made into the property C (A+B) that the property B of the Raman gain by the 2nd optical amplification by the 2nd excitation light 12 was added to this when the Raman gain by the 1st optical amplification formed of the 1st excitation light 11 was the property A shown in drawing 2 , and the total and big signal magnification effectiveness is acquired.

[0031] Also with each operation gestalt explained below, although it is the same, according to this invention, the following effectiveness is also acquired.

[0032] First, according to this invention, the gain improvement effect of the optical amplification property by excitation light is acquired. That is, in the above-mentioned magnification function, although what is necessary is just to increase excitation light reinforcement to raise gain since magnification gain increases as excitation light reinforcement is increased, since there are a limitation original with an amplifier and constraint, gain will be saturated with a certain level. For example, as the dotted line of drawing 3 shows, although gain increases [specific excitation light reinforcement] proportionally to E1 (mW) in the conventional amplifier (for example, optical fiber amplifiers, such as EDF), if excitation light reinforcement exceeds E1, gain will be saturated with G1 and even if it makes it increase more than it, will not increase more than it. Therefore, even if it was possible more to output a strong big excitation light to the light sources (laser diode etc.) which output excitation light, a part for the allowances was fully unutilizable.

[0033] On the other hand, in this invention, since the 2nd optical amplification (for example, Raman amplifier) by the 2nd excitation light is further used for the 1st optical amplification (for example, optical fiber amplifier) by the 1st excitation light, gain will continue increasing until it results in the reinforcement E2 beyond excitation light on-the-strength E1, as the continuous line of drawing 3 shows. Therefore, the gain by the Raman magnification is added, excitation light is used effectively (to the excitation light reinforcement E2), and, even as for the saturation gain G2 of the Raman magnification, bigger gain is acquired.

[0034] Moreover, according to this invention, the improvement effect of the gain inclination of an optical amplification property is acquired. The property Fig. showing the wavelength for explaining this effectiveness and the relation of gain is shown in drawing 4 . as the gain property of optical fiber magnification as conventional amplifier shows by (A), when it is the property that wavelength becomes long and that it is alike, and follow and gain falls, as shown in (B), wavelength becomes long conversely about the gain property of the Raman

magnification -- if it adjusts so that it is alike, and may follow and may become high -- after all -- the inclination of both properties -- denying -- it is -- a total -- if -- abbreviation -- a fixed gain property (A+B) is acquired. This total property can be made into a desired property if a magnification property is adjusted to arbitration.
[0035] Furthermore, according to this invention, the band expansion effectiveness of an optical amplification property is acquired. This effectiveness is explained with reference to drawing 5 which shows wavelength and the relation of gain. Although drawing 5 is the same drawing as drawing 4 , a total property has an inclination.
[0036] If the gain difference permitted on a system design is set to deltaG, the wavelength band of the property (A) at the time of using the optical fiber magnification as amplifier conventionally will be set to A. On the other hand, if the property (B) by the Raman magnification in this invention is taken into consideration, the inclination of a total property (C) will become loose, after all, if a permissible gain difference is made into deltaG', as for the wavelength band at the time of using the conventional optical fiber magnification, the wavelength band B will be added at A, a total wavelength band will serve as C (= A+B), and the remarkable band expansion effectiveness will be acquired.
[0037] The above various effectiveness is similarly acquired in all the operation gestalten explained below.
[0038] Next, the optical repeating installation 101 by the gestalt of operation of the 2nd of this invention is explained using drawing 6 . This operation gestalt is the optical repeater 101 which changed a part of configuration of the optical repeating installation 100 shown in drawing 1 . That is, it faces pouring into the multiplexing machine 4 the 2nd excitation light 12 outputted from a spectroscope 10, and the 2nd optical amplification means is constituted by inserting an optical attenuator 13 all over the track of the 2nd excitation light 12.
[0039] Therefore, the Raman gain by the 2nd optical amplification by the 2nd excitation light 12 can be set as the optimal value by pouring into a lightwave signal 3 the attenuation light 14 obtained by adjusting the output of the 2nd excitation light 12 outputted from a spectroscope 10 with an optical attenuator 13 with the multiplexing vessel 4.
[0040] A control circuit 1 controls the attenuation level of the excitation reinforcement and the optical attenuator 13 which are outputted from the excitation light source 8 by the control signal from the outside, and optimizes a magnification property.
[0041] Next, the optical repeating installation 102 by the gestalt of operation of the 3rd of this invention is explained using drawing 7 . the adjustable turnout 15 which faces [carrying out the spectrum of the excitation light 9 which is the optical repeater 102 which changed a part of configuration of the optical repeating installation 1 shown in drawing 1 , and is emitted from the excitation light source 8 to two excitation light] this operation gestalt, and can carry out adjustable [of the branching ratio] -- containing -- a spectrum -- a means is constituted.
[0042] In case this adjustable turnout 15 carries out the spectrum of the excitation

light 9 outputted from the excitation light source 8 to the 1st excitation light 11 and the 2nd excitation light 16, it is what could be made to carry out adjustable [of that branching ratio]. By pouring into the multiplexing machine 4 the output of the 2nd excitation light 16 outputted from the adjustable turnout 15 in the condition of having adjusted to the optimal value, the Raman gain by the 2nd optical amplification by the 2nd excitation light 16 can be maintained at the optimal value. This is interlocked with, and since the branching ratio of the 1st excitation light 11 is also made the optimal value by the adjustable turnout 15, the Raman gain by the 1st optical amplification by the 1st excitation light 11 can also be maintained at the optimal value.
[0043] A control circuit 1 controls the excitation reinforcement and the adjustable turnout 15 which are outputted from the excitation light source 8 by the control signal from the outside, and optimizes a magnification property.
[0044] Next, the optical repeating installation 103 by the gestalt of operation of the 4th of this invention is explained using drawing 8 . This operation gestalt is what was constituted as optical repeating installation 103 as combined so that the function by the gestalt of the 2nd operation shown in drawing 2 and the function by the gestalt of the 3rd operation shown in drawing 6 may be combined, and shown in drawing 8 . The excitation light 9 emitted from the excitation light source 8 is branched to two, the 1st excitation light 11 and the branching light 18, by the adjustable turnout 17, and the 2nd optical amplification means is constituted by inserting an optical attenuator 19 in the latter part of the path of this branching light 18.
[0045] moreover, the adjustable turnout 17 which faces [carrying out the spectrum of the excitation light 9 emitted from the excitation light source 8 to two excitation light] the optical repeating installation 103, and can carry out adjustable [of the branching ratio] -- containing -- a spectrum -- a means is constituted.
[0046] Therefore, the Raman gain by the 2nd optical amplification by the 2nd excitation light 20 can be set as the optimal value by pouring into a lightwave signal 3 the 2nd excitation light 20 obtained by adjusting the output of the branching light 18 outputted from the adjustable turnout 17 with an optical attenuator 19 with the multiplexing vessel 4.
[0047] Moreover, since the adjustable turnout 17 is poured into the multiplexing machine 4 where the output of the branching light 18 outputted from the adjustable turnout 17 is adjusted to the optimal branching ratio, since it carried out adjustable [of the branching ratio] in case it carries out the spectrum of the excitation light 9 outputted from the excitation light source 8 to two, the 1st excitation light 11 and the branching light 18, it can maintain the Raman gain by the 2nd optical amplification by the 2nd excitation light 20 at the optimal value. This is interlocked with, and since the branching ratio of the 1st excitation light 11 is also made the optimal value by the adjustable turnout 17, the Raman gain by the 1st optical amplification by the 1st excitation light 11 can also be maintained at the optimal value.
[0048] By pouring in the 1st excitation light 11 by the part of the fiber 5 for optical amplification to the lightwave signal 3 by which the input-line way 2 is spread,

Raman magnification which contributes to optical amplification like the conventional optical repeating installation is performed, and secondary optical amplification is performed by pouring the 2nd excitation light 20 into the lightwave signal 3 which spreads the fiber 5 for optical amplification on this and a coincidence target.
[0049] A control circuit 1 controls the attenuation level of the excitation reinforcement outputted from the excitation light source 8 by the control signal from the outside, the adjustable turnout 17, and an optical attenuator 19, and optimizes a magnification property.
[0050] Next, the optical repeating installation 104 by the gestalt of operation of the 5th of this invention is explained using drawing 9 . This operation gestalt is what changed a part of configuration of the optical repeating installation 101 shown in drawing 1 , and constituted the optical repeating installation 104, namely, is faced pouring into the multiplexing machine 4 the 2nd excitation light 12 outputted from a spectroscope 10, and constitutes the 2nd optical amplification means by inserting an optical amplifier 21 all over the track of the 2nd excitation light 12.
[0051] Therefore, the Raman gain by the 2nd optical amplification based on the 2nd excitation light 12 can be set as the optimal value by pouring into a lightwave signal 3 the magnification light 22 obtained by adjusting the output of the 2nd excitation light 12 outputted from a spectroscope 10 with an optical amplifier 21 with the multiplexing vessel 4.
[0052] A control circuit 1 controls the excitation reinforcement and the optical amplifier 21 which are outputted from the excitation light source 8 by the control signal from the outside, and optimizes a magnification property.
[0053] Next, the optical repeating installation 105 by the gestalt of operation of the 6th of this invention is explained. This operation gestalt is constituted like the optical repeating installation 105 which is shown in drawing 1 and which changes a part of 1st configuration of the optical repeating installation 101 of the gestalt of operation, and is shown in drawing 10 .
[0054] Namely, the optical repeating installation 105 is what considered the condition of pouring in the 1st excitation light 11 to the fiber 5 for optical amplification as front excitation. With a spectroscope 10, a spectrum is carried out to the 1st excitation light 11 and the 2nd excitation light 12, the excitation light 24 emitted from the excitation light source 23 uses the multiplexing machine 6 in the direction as the propagation direction of a lightwave signal 3 where this 1st excitation light 11 is the same, is poured into it, and Raman magnification is performed in the state of front excitation.
[0055] On the other hand, if the 2nd excitation light 12 by which the spectrum was carried out with the spectroscope 10 is shown in drawing 1 , similarly, the multiplexing machine 4 will be used in the same direction as the propagation direction of a lightwave signal 3, it will be poured into it, and secondary Raman magnification will be performed in the state of back excitation.
[0056] A control circuit 1 controls the excitation reinforcement outputted from the excitation light source 23 by the control signal from the outside, and optimizes a magnification property.

[0057] Next, the optical repeating installation 106 by the gestalt of operation of the 7th of this invention is explained using drawing 11 . This operation gestalt is what was used as the optical repeating installation 106 which changes a part of configuration of the optical repeating installation 101 shown in drawing 6 , and is shown in drawing 11 . Namely, while constituting the 2nd optical amplification means by facing pouring into the multiplexing machine 4 the 2nd excitation light 12 outputted from a spectroscope 10, and inserting an optical attenuator 13 all over the track of the 2nd excitation light 12 The optical repeating installation 106 is what considered the condition of pouring in the 1st excitation light 11 to the fiber 5 for optical amplification as front excitation. With a spectroscope 10, a spectrum is carried out to the 1st excitation light 11 and the 2nd excitation light 12, the excitation light 26 emitted from the excitation light source 25 uses the multiplexing machine 6 in the direction as the propagation direction of a lightwave signal 3 where this 1st excitation light 11 is the same, is poured into it, and Raman magnification is performed in the state of front excitation.
[0058] On the other hand, the 2nd excitation light 12 by which the spectrum was carried out with the spectroscope 10 can set the Raman gain by the 2nd optical amplification by the 2nd excitation light 12 as the optimal value by being poured in using the multiplexing machine 6 in the state of back excitation [with the multiplexing vessel 4] of the attenuation light 14 obtained by adjusting with an optical attenuator 13 in a direction contrary to the propagation direction of a lightwave signal 3.
[0059] A control circuit 1 controls the attenuation level of the excitation reinforcement and the optical attenuator 13 which are outputted from the excitation light source 25 by the control signal from the outside, and optimizes a magnification property.
[0060] Next, the optical repeating installation 107 by the gestalt of operation of the 8th of this invention is explained using drawing 12 . This operation gestalt is what was used as the optical repeating installation 107 which changes a part of configuration of the optical repeating installation 102 shown in drawing 7 , and is shown in drawing 9 . namely, the adjustable turnout 15 which faces carrying out the spectrum of the excitation light 28 emitted from the excitation light source 27 to two excitation light, and can carry out adjustable [of the branching ratio] -- containing -- a spectrum, while constituting a means By this adjustable turnout 15, the 1st excitation light 11 by which adjustable branching was carried out is poured into an optimum value on the occasion of impregnation at a lightwave signal 3 in the state of front excitation in the same direction as the propagation direction of the lightwave signal 3 concerned, and Raman magnification is performed.
[0061] Moreover, it faces pouring into the multiplexing machine 4 the branching light 16 outputted from the adjustable turnout 15, and Raman magnification is performed in the condition of having been poured in in the direction contrary to the propagation direction of a lightwave signal 3 using the multiplexing machine 4 in the state of back excitation.
[0062] In this case, in case the adjustable turnout 15 carries out the spectrum of the excitation light 28 outputted from the excitation light source 27 to the 1st excitation

light 11 and the 2nd excitation light 16, it is what could be made to carry out adjustable [of that branching ratio]. By pouring into the multiplexing machine 4 the output of the 2nd excitation light 16 outputted from the adjustable turnout 15 in the condition of having adjusted to the optimal value, the Raman gain by the 2nd optical amplification by the 2nd excitation light 16 can be maintained at the optimal value. This is interlocked with, and since the branching ratio of the 1st excitation light 11 is also made the optimal value by the adjustable turnout 15, the Raman gain by the 1st optical amplification by the 1st excitation light 11 can also be maintained at the optimal value.
[0063] A control circuit 1 controls the excitation reinforcement and the adjustable turnout 15 which are outputted from the excitation light source 27 by the control signal from the outside, and optimizes a magnification property.
[0064] Next, the optical repeating installation 108 by the gestalt of operation of the 9th of this invention is explained using drawing 13 . This operation gestalt is what was used as the optical repeating installation 108 as changed a part of configuration of the optical repeating installation 103 by the gestalt of the 4th operation shown in drawing 8 and shown in drawing 13 . The excitation light 30 emitted from the excitation light source 29 namely, by the adjustable turnout 17 It faces pouring into the multiplexing machine 4 side the branching light 18 of the 1st excitation light 11 from which the branching ratio was set up the optimal and obtained, and the branching light 18, and the 2nd optical amplification means is constituted by inserting an optical attenuator 19 all over the track.
[0065] Moreover, this optical repeating installation 108 is what considered the condition of pouring in the 1st excitation light 11 to the fiber 5 for optical amplification as front excitation. A spectrum is carried out to the 1st excitation light 11 and the branching light 18, the excitation light 30 emitted from the excitation light source 29 uses the multiplexing machine 6 in the direction as the propagation direction of a lightwave signal 3 where this 1st excitation light 11 is the same, is poured into it by the adjustable turnout 17, and Raman magnification is performed in the state of front excitation.
[0066] On the other hand, the branching light 18 by which the spectrum was carried out by the adjustable turnout 17 can set the Raman gain by the 2nd optical amplification by the 2nd excitation light 12 as the optimal value by being poured in in the state of back excitation [with the multiplexing vessel 4] of the 2nd excitation light 20 obtained by adjusting with an optical attenuator 19 in a direction contrary to the propagation direction of a lightwave signal 3.
[0067] A control circuit 1 controls the attenuation level of the excitation reinforcement outputted from the excitation light source 29 by the control signal from the outside, the adjustable turnout 17, and an optical attenuator 19, and optimizes a magnification property.
[0068] Next, the optical repeating installation 109 by the gestalt of operation of the 10th of this invention is explained using drawing 14 . This operation gestalt is what constituted the optical repeating installation 109 as changed a part of configuration of the optical repeating installation 104 shown in drawing 6 and shown in drawing 11 , namely, faces pouring into a multiplexing machine 4 the 2nd excitation light 12

outputted by carrying out the spectrum of the excitation light 32 emitted from the excitation light source 31 with a spectroscope 10, and constitutes the 2nd optical-amplification means by inserting an optical amplifier 21 all over the track of the 2nd excitation light 12.
[0069] Moreover, in case the condition of pouring in the 1st excitation light 11 to the fiber 5 for optical amplification is considered as front excitation and the magnification light 22 by the optical amplifier 21 is inputted into the multiplexing machine 4, this optical repeating installation 109 is constituted so that impregnation may be performed in the direction contrary to the propagation direction of a lightwave signal 3 in the state of back excitation.
[0070] Therefore, with a spectroscope 10, a spectrum is carried out to the 1st excitation light 11 and the 2nd excitation light 12, the excitation light 32 emitted from the excitation light source 31 uses the multiplexing machine 6 in the direction as the propagation direction of a lightwave signal 3 where this 1st excitation light 11 is the same, is poured into it, and Raman magnification is performed in the state of front excitation.
[0071] On the other hand, the 2nd excitation light 12 by which the spectrum was carried out with the spectroscope 10 can set the Raman gain by the 2nd optical amplification by the 2nd excitation light 12 as the optimal value by being poured in in the state of back excitation [with the multiplexing vessel 4] of the magnification light 22 which was adjusted by the optimal amplification factor with the optical amplifier 21, and was obtained in a direction contrary to the propagation direction of a lightwave signal 3.
[0072] A control circuit 1 controls the excitation reinforcement outputted from the excitation light source 61 by the control signal from the outside, and optimizes a magnification property.
[0073] Next, the optical repeating installation 110 by the gestalt of operation of the 11th of this invention is explained using drawing 15 . When shown between the 1st input-line way 41 and the 1st output track 46 at drawing 1 , the same multiplexing machine 43, When the multiplexing machine 45 is connected with the fiber 44 for optical amplification one by one, the 1st optical transmission system is constituted and it is shown in coincidence also between the 2nd input-line way 51 and the 2nd output track 56 at drawing 1 , the same multiplexing machine 53, The multiplexing machine 55 is connected with the fiber 54 for optical amplification one by one, and the 2nd optical transmission system is constituted, and the optical repeating installation 110 is inserted in these, and it is constituted.
[0074] the spectrum for such 1st and 2nd optical transmission systems being alike, respectively, and receiving and carrying out Raman magnification -- the means is established.
[0075] The spectrum of the excitation light 62 by which the optical means was emitted from the excitation light source 61 is carried out to the 1st excitation light 64 and the 2nd excitation light 65 with a spectroscope 63 at this rate. The 1st optical amplification means which branches the 1st excitation light 64 in the 1st light 67 and the 2nd light 68 with a spectroscope 66, pours the 1st light 67 into the 1st lightwave signal 42 in the state of back excitation with the multiplexing vessel

45, and pours the 2nd light 68 into the 2nd lightwave signal 52 in the state of back excitation using the multiplexing machine 55 is constituted.
[0076] Moreover, the 2nd excitation light 65 which branched with the spectroscope 63 pours the 1st light 70 into the 1st lightwave signal 42 in the state of back excitation with the multiplexing vessel 43 by branching in the 1st light 70 and the 2nd light 71 with a spectroscope 69, and the 2nd optical amplification means poured into the 2nd lightwave signal 52 in the state of back excitation with the multiplexing vessel 53 is constituted in the 2nd light 71.
[0077] A control circuit 1 controls the excitation reinforcement outputted from the excitation light source 61 by the control signal from the outside, and optimizes a magnification property.
[0078] therefore, the excitation light 62 from the one excitation light source 61 -- using -- the 1st and 2nd optical transmission systems -- respectively -- alike -- receiving -- the Raman magnification -- it can carry out -- the spectrum of this ** -- since a means can be shared and used for two lines, common use-ization of a configuration can be attained.
[0079] Next, the optical repeating installation 111 by the gestalt of operation of the 12th of this invention is explained using drawing 16 . this gestalt -- a spectrum -- the 1st excitation light and the 2nd excitation light are made by compounding and carrying out the spectrum of two or more excitation light emitted from two or more excitation light sources in the configuration of a means.
[0080] That is, the 1st excitation light source 81 and the 2nd excitation light source 82 are formed, and the output is compounded with the synthetic vessel 85, it is inputted into a spectroscope 88 as a synthetic light 87, and the 1st excitation light 90 is made by the optical repeating installation 111 inserted between the input-line way 2 and the output track 7.
[0081] On the other hand, the 3rd excitation light source 83 and the 4th excitation light source 84 are formed, the output is compounded with the synthetic vessel 86, it is inputted into a spectroscope 88 as a synthetic light 89, and the branching light 88 is made. The 2nd excitation light 93 is made by decreasing this branching light 88 with an optical attenuator 92.

[0082] Therefore, Raman magnification by the 1st optical amplification means is performed by pouring into a lightwave signal 3 the 1st excitation light 90 which comes to compound each output of the 1st excitation light source 81 and the 2nd excitation light source 82 in the state of back excitation using the multiplexing machine 6.
[0083] Secondary Raman magnification by the 2nd optical amplification means is performed by pouring into a lightwave signal 3 the 2nd excitation light 93 which it comes to decrease to an optimum value after compounding each output of the 3rd excitation light source 83 and the 4th excitation light source 84 on this and a coincidence target in the state of back excitation using the multiplexing machine 4.
[0084] A control circuit 1 controls the attenuation level of the excitation reinforcement and the optical attenuator 92 which are outputted from the excitation light sources 81-84 by the control signal from the outside, and optimizes a

magnification property.

[0085] The lightwave transmission system in which the above optical repeating installation was arranged in at intervals of predetermined along the transmission line, and had the description like the above and a predominance is constituted. Arrangement of this optical repeating installation is arbitrary, and can be arranged in one of the junction sections.

[0086]

[Effect of the Invention] By the above explanation, the optical repeating installation by this invention so that clearly It faces obtaining the predetermined Raman magnification function by the 1st and 2nd optical amplification. Since each of the 1st excitation light for performing the 1st optical amplification as a spectroscope is also about the excitation light emitted from the one excitation light source, and the 2nd excitation light for performing the 2nd optical amplification is made It not only can attain simplification of a configuration, but the optimal property is acquired by adjusting the 1st excitation light and the 2nd excitation light concerned.

[0087] Therefore, according to this invention, the one excitation light source can be used and the optical repeating installation and the lightwave transmission system which can perform the 1st optical amplification and 2nd optical amplification instantaneous can be offered.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] It is the block diagram showing the configuration of the optical repeating installation by the gestalt of operation of the 1st of this invention.

[Drawing 2] It is the property Fig. showing the Raman magnification property of the optical repeating installation by this invention.

[Drawing 3] It is a property Fig. for explaining the gain improvement effect of the optical amplification property by the excitation light in this invention.

[Drawing 4] It is drawing for explaining the improvement effect of the gain inclination of the optical amplification property in this invention.

[Drawing 5] It is a property Fig. for explaining the band expansion effectiveness of the optical amplification property in this invention.

[Drawing 6] It is the block diagram showing the configuration of the optical repeating installation by the gestalt of operation of the 2nd of this invention.

[Drawing 7] It is the block diagram showing the configuration of the optical

repeating installation by the gestalt of operation of the 3rd of this invention.
[Drawing 8] It is the block diagram showing the configuration of the optical repeating installation by the gestalt of operation of the 4th of this invention.
[Drawing 9] It is the block diagram showing the configuration of the optical repeating installation by the gestalt of operation of the 5th of this invention.
[Drawing 10] It is the block diagram showing the configuration of the optical repeating installation by the gestalt of operation of the 6th of this invention.
[Drawing 11] It is the block diagram showing the configuration of the optical repeating installation by the gestalt of operation of the 7th of this invention.
[Drawing 12] It is the block diagram showing the configuration of the optical repeating installation by the gestalt of operation of the 8th of this invention.
[Drawing 13] It is the block diagram showing the configuration of the optical repeating installation by the gestalt of operation of the 9th of this invention.
[Drawing 14] It is the block diagram showing the configuration of the optical repeating installation by the gestalt of operation of the 10th of this invention.
[Drawing 15] It is the block diagram showing the configuration of the optical repeating installation by the gestalt of operation of the 11th of this invention.
[Drawing 16] It is the block diagram showing the configuration of the optical repeating installation by the gestalt of operation of the 12th of this invention.
[Description of Notations]
100-111 Optical repeating installation
1 Control Circuit
2 Input-Line Way
3 Lightwave Signal
4 Six Multiplexing machine
5 Fiber for Optical Amplification
7 Output Track
8, 23, 25, 27, 29, 31, 61, 81-84 Excitation light source
9 Excitation Light
10 Spectroscope
15 17 Adjustable turnout
11 1st Excitation Light
12 2nd Excitation Light
13, 19, 93 Optical attenuator
21 Optical Amplifier
85 86 Synthetic vessel

[Translation done.]

DRAWINGS

[Drawing 1]

[Drawing 2]

[Drawing 3]

[Drawing 4]

[Drawing 5]

[Drawing 6]

[Drawing 7]

[Drawing 8]

[Drawing 9]

[Drawing 10]

[Drawing 11]

[Drawing 12]

[Drawing 13]

[Drawing 14]

[Drawing 15]

[Drawing 16]

[Translation done.]